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Pseudorapidity dependence of charged hadron transverse momentum spectra in d+Au collisions at $\sqrt{s_{NN}}$=200 GeV

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We have measured the transverse momentum distributions of charged hadrons in d+Au collisions at $\sqrt{s_{NN}}$ =200 GeV in the range of $0.5 < p_T < 4.0$ GeV/c. The total range of pseudorapidity, η, is $0.2 < \eta < 1.4$, where positive η is in the deuteron direction. The data has been divided into three regions of pseudorapidity, covering $0.2 < \eta < 0.6$, $0.6 < \eta < 1.0$, and $1.0 < \eta < 1.4$, and has been compared to charged hadron spectra from $p+\overline{p}$ collisions at the same energy. There is a significant change in the spectral shape as a function of pseudorapidity. As η increases we see a decrease in the nuclear modification factor R_{dAu}.

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The yields of charged hadrons from d+Au collisions at $\sqrt{s_{NN}}$=200 GeV from the Relativistic Heavy Ion Collider (RHIC) have been measured by PHOBOS as a function of pseudorapidity, η, and transverse momentum, p_T. One of the goals of the d+Au run was to determine whether the suppression relative to the number of binary nucleon-nucleon collisions (N_{coll}) seen in the high p_T region in Au+Au collisions [1–5] was due to initial-state effects, such as parton saturation [6], or due to final-state effects of particles interacting with the dense medium produced in the collision [7].

If supression at high p_T in Au+Au data was caused by initial-state effects, a suppression would also be seen in the d+Au data from peripheral to central collisions [8]. The fact that no suppression was seen [9–12] leads to the conclusion that the suppression in Au+Au data was due to interactions in the final state.

The d+Au results from midrapidity [10–12] show an enhancement at high p_T similar to data from lower energies [13], while the results from PHOBOS [9], which have an average pseudorapidity of 0.8, show no clear enhancement at high p_T. A more detailed study as a function of η was performed in order to investigate this difference in the data. In addition, it has been predicted that parton saturation effects, while not responsible for the suppression seen in the midrapidity Au+Au data, might cause a decrease in the particle yields at high rapidity in p+A and d+A relative to $p+p$ collisions [14]. In this paper we average the data presented in [9] over centrality, divide it into three different bins of pseudorapidity, $0.2 < \eta < 0.6$, $0.6 < \eta < 1.0$, and $1.0 < \eta < 1.4$, and amine the yields relative to $p+\overline{p}$ collisions for each region.

This analysis was nearly identical to that of [9], with three important changes. First, we omitted the events triggered by high p_T particles, which traverse the spectrometer due to the limited η acceptance of the time-of-flight walls. Second, the corrections to the spectra for geometrical acceptance, tracking efficiency, momentum resolution, and binning distortion were determined and applied separately for each pseudorapidity bin. Finally, we averaged over centralities and calculated N_{coll} (the average number of binary collisions) using a weighted average with the number of events in each centrality bin. The mean N_{coll} in these data is 9.5 ± 0.8 (systematic). The vertex range along the beam axis of the data used in this analysis is $-10\text{ cm} < z_{vtx} < 10$ cm with respect to the nominal interaction point. Since the z_{vtx} and the accepted range of η in the spectrometer are highly correlated, the different η regions correspond to different ranges in z_{vtx}. The ranges in z_{vtx} for the different η bins are shown in Table I.

In Fig. 1 we show the nuclear modification factor R_{dAu} for charged hadrons, defined as

TABLE I. Ranges in z_{vtx}, the position of the vertex along the beam axis, used for the different pseudorapidity bins.

η range	Range in z_{vtx} (cm)
$0.2<\eta<0.6$	$0<z_{vtx}<10$
$0.6<\eta<1.0$	$-10<z_{vtx}<5$
$1.0<\eta<1.4$	$-10<z_{vtx}<5$

$$R_{dAu} = \frac{\sigma_{pp}^{inel}}{\langle N_{coll}\rangle} \frac{d^2N_{dAu}/dp_T\, d\eta}{d^2\sigma(\mathrm{UA1})_{p\bar{p}}/dp_T\, d\eta}, \tag{1}$$

for the three different η bins. The $p+\bar{p}$ reference data used is from UA1 at 200 GeV [15]. Since the UA1 acceptance ($|\eta|<2.5$) is quite different from the PHOBOS spectrometer acceptance, we applied a correction to the UA1 spectra [9], which was determined using the PYTHIA event generator [16]. A separate correction to the UA1 data was generated for each of the different η bins. The decrease seen in R_{dAu} with increasing pseudorapidity is qualitatively consistent with the predictions of the parton saturation model [14], as well as with the data from the BRAHMS experiment [17], which extend to $\eta=3.2$.

To further understand the evolution of R_{dAu} with pseudorapidity we have plotted the values of R_{dAu} for different p_T values as a function of η, shown in Fig. 2. A function was fit to the spectra, which consisted of the sum of an exponential and a power law. This fit was then divided by a fit to the corrected UA1 data. The ratio of the values of these two fit functions are plotted at four different values of p_T as a function of η. We see a smooth decrease in R_{dAu} from mid to high pseudorapidity. The gray error bands represent the correlated scale errors for the different η bins at the given p_T. The main contributions to these errors are the error on N_{coll} and the global uncertainty in the acceptance and efficiency correction. The error bars show the uncorrelated point-to-point errors between the η bins. These are dominated by the uncertainty in the η dependence of the acceptance and efficiency corrections, the dead channel correction, and the momentum resolution corrections.

In summary, we have measured the pseudorapidity dependence of the nuclear modification factor derived from the yield of charged hadrons produced in d+Au collisions at $\sqrt{s_{NN}}=200$ GeV. A smooth decrease of R_{dAu} with increasing pseudorapidity has been observed. The details of the evolution of R_{dAu} as a function of transverse momentum and pseudorapidity can be used to evaluate and constrain models including saturation effects.

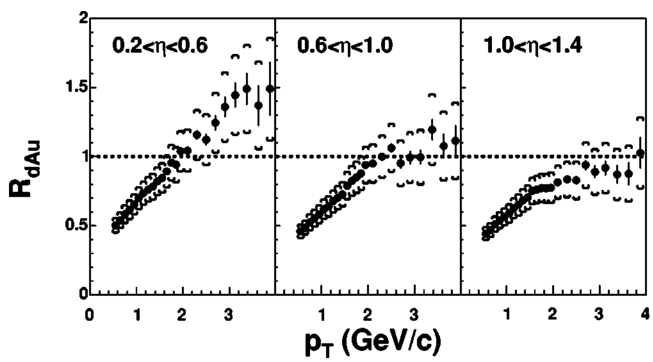

FIG. 1. Nuclear modification factor R_{dAu} for three different pseudorapidity ranges. The brackets show the systematic uncertainty (90% C.L.).

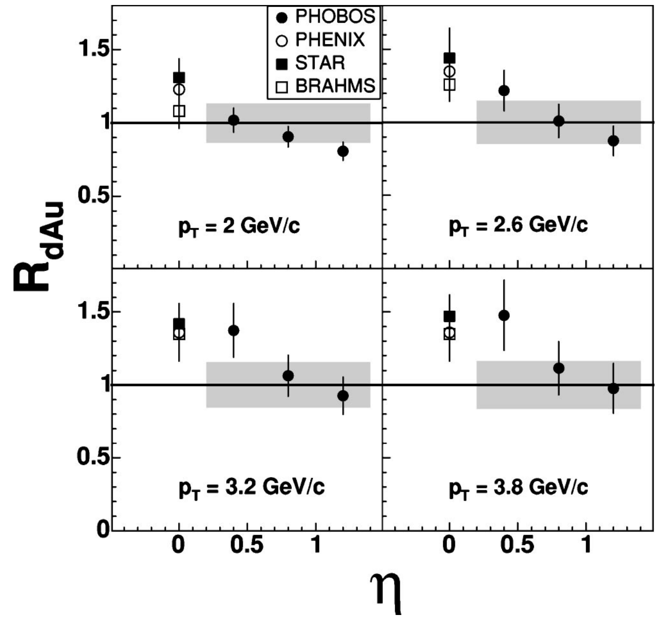

FIG. 2. Nuclear modification factor R_{dAu} for four different values of p_T for the three different η bins. The error bands show the common systematic scale errors (90% C.L.) for the PHOBOS data. The error bars show the systematic point-to-point uncertainty (90% C.L.) of the fitted data points. PHENIX, STAR, and BRAHMS points are from Refs. [10–12].

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